CLAIMS

1. A nuclear magnetic resonance probe circuit comprising:

    a first resonator resonant at a frequency f_1;

    a second resonator having a magnetic field generating component and being resonant at a frequency f_2 that is higher than f_1; and

    a third resonator resonant at a frequency f_3 that is higher than f_2, wherein the resonances of the first, second and third resonators interact to produce two intermediate resonances, respectively, at a frequency f_{12} between frequency f_1 and f_2, and a frequency f_{23} between frequency f_2 and f_3 such that, when signals at f_{12} and f_{23} are coupled into the circuit, the circuit resonates at f_{12} and f_{23} and magnetic fields are generated by the magnetic field generating element at frequency f_{12} and frequency f_{23}.

2. A probe circuit according to Claim 1 wherein the magnetic field generating element comprises an inductive sample coil.

3. A probe circuit according to Claim 1 wherein the first resonator comprises a transmission line.

4. A probe circuit according to Claim 1 wherein each of the first resonator and the third resonator comprise a transmission line, respectively.

5. A probe circuit according to Claim 4 wherein the first resonator is electrically adjacent to a first input port for frequency f_{12} and the third resonator is electrically adjacent to a second input port for frequency f_{23}.

6. A probe circuit according to Claim 5 further comprising a first admittance inverter located electrically between the first input port and a first electrical side of the second resonator.

7. A probe circuit according to Claim 6 wherein the first admittance inverter comprises a transmission line.

8. A probe circuit according to Claim 6 further comprising a second admittance inverter located electrically between the second input port and a second electrical side of the second resonator.

9. A probe circuit according to Claim 8 wherein the second admittance inverter comprises a transmission line.

10. A probe circuit according to Claim 9 wherein the first resonator transmission line has null points for frequencies f_{12} and f_{23} in close physical proximity to each other, and wherein the circuit further comprises a third input port for resonant frequency f_x coupled to the first resonator transmission line in the vicinity of said null points such that, when a third input signal at frequency f_x is coupled to the third input port, a magnetic field is generated by the magnetic field generating element at frequency f_x.

11. A probe circuit according to Claim 9 wherein the second admittance inverter transmission line has null points for frequencies f_{12} and f_{23} in close physical proximity to each other, and wherein the circuit further comprises a third input port for resonant frequency f_y coupled to the first resonator transmission line in the vicinity of said null points such that, when a third input signal at frequency f_y is input to the third input port, a magnetic field is generated by the magnetic field generating element at frequency f_y.

12. A probe circuit according to Claim 1 wherein f_{12} and f_{23} are each above 400 MHz.

13. A probe circuit according to Claim 1 wherein f_{12} and f_{23} are within 10% of each other in frequency.

14. A nuclear magnetic resonance probe circuit for generating resonant magnetic fields at a first frequency f_{12} and a second frequency f_{23}, the circuit comprising:

a first resonator resonant at a frequency f_1 that is lower than f_{12};

a second resonator having a magnetic field generating component from which the resonant magnetic fields originate, the resonator being resonant at a frequency f_2 that is higher than f_1 and f_{12}, but lower than f_{23}; and

a third resonator resonant at a frequency f_3 that is higher than f_{23}, wherein the first, second and third resonators are arranged in the circuit relative to one another such that they are in a parallel combination or in a combination that is the electrical equivalent of a parallel combination.

15. A probe circuit according to Claim 14 wherein the magnetic field generating element comprises an inductive sample coil.

16. A probe circuit according to Claim 14 wherein the first resonator comprises a transmission line.

17. A probe circuit according to Claim 14 wherein each of the first resonator and the third resonator comprise a transmission line, respectively.

18. A probe circuit according to Claim 17 wherein the first resonator is electrically adjacent to a first input port for frequency f_{12} and the third resonator is electrically adjacent to a second input port for frequency f_{23}.

19. A probe circuit according to Claim 18 further comprising a first admittance inverter located electrically between the first input port and a first electrical side of the second resonator.

20. A probe circuit according to Claim 19 wherein the first admittance inverter comprises a transmission line.

21. A probe circuit according to Claim 19 further comprising a second admittance inverter located electrically between the second input port and a second electrical side of the second resonator.

22. A probe circuit according to Claim 21 wherein the second admittance inverter comprises a transmission line.

23. A probe circuit according to Claim 22 wherein the first resonator transmission line has null points for frequencies f_{12} and f_{23} in close physical proximity to each other, and wherein the circuit further comprises a third input port for resonant frequency f_x coupled to the first resonator transmission line in the vicinity of said null points such that, when a third input signal at frequency f_x is coupled to the third input port, a magnetic field is generated by the magnetic field generating element at frequency f_x.

24. A probe circuit according to Claim 22 wherein the second admittance inverter transmission line has null points for frequencies f_{12} and f_{23} in close physical proximity to each other, and wherein the circuit further comprises a third input port for resonant frequency f_y coupled to the first resonator transmission line in the vicinity of said null points such that, when a third input signal at frequency f_y is coupled to the third input port, a magnetic field is generated by the magnetic field generating element at frequency f_y.

25. A probe circuit according to Claim 14 wherein f_{12} and f_{23} are each above 400MHz.

26. A probe circuit according to Claim 14 wherein f_{12} and f_{23} are within 10% of each other in frequency.

27. A method of generating a plurality of high frequency magnetic fields for a nuclear magnetic resonance probe, the method comprising:

providing a probe circuit having a first resonator resonant at a frequency f_1, a second resonator that has a magnetic field generating component and is resonant at a frequency f_2 that is higher than f_1, and a third resonator resonant at a frequency f_3 that is higher than f_2, the resonances of the three resonators giving rise to intermediate resonances at frequency f_{12}, between frequencies f_1 and f_2, and frequency f_{23}, between frequencies f_2 and f_3; and

coupling a first signal at frequency f_{12} and a second signal at frequency f_{23} to the circuit such that magnetic fields are generated by the magnetic field generating element at frequency f_{12} and frequency f_{23}.

28. A method according to Claim 27 wherein the magnetic field generating element comprises an inductive sample coil.

29. A method according to Claim 27 wherein each of the first resonator and the third resonator comprise a transmission line, respectively.

30. A method according to Claim 29 wherein the first resonator is electrically adjacent to a first input port for the first signal and the third resonator is electrically adjacent to a second input port for the second signal.

31. A method according to Claim 30 further comprising locating a first admittance inverter electrically between the first input port and a first electrical side of the second resonator and a second admittance inverter electrically between the second input port and a second electrical side of the second resonator.

32. A method according to Claim 31 wherein the first admittance inverter and the second admittance inverter each comprise a transmission line.

33. A method according to Claim 32 wherein the first resonator transmission line has null points for frequencies f_{12} and f_{23} in close physical proximity to each other, and wherein the method further comprises coupling a third input signal at

frequency f_x to a third input port electrically connected to the first resonator transmission line in the vicinity of said null points such that, when a third input signal at frequency f_x is coupled to the third input port, a magnetic field is generated by the magnetic field generating element at frequency f_x.

34. A method according to Claim 32 wherein the second admittance inverter transmission line has null points for frequencies f_{12} and f_{23} in close physical proximity to each other, and wherein the method further comprises coupling a third input signal at frequency f_y to a third input port electrically connected to the first resonator transmission line in the vicinity of said null points such that, when a third input signal at frequency f_y is coupled to the third input port, a magnetic field is generated by the magnetic field generating element at frequency f_y.

35. A method according to Claim 27 wherein f_{12} and f_{23} are each above 400MHz.

36. A method according to Claim 27 wherein f_{12} and f_{23} are within 10% of each other in frequency.

37. A method for generating resonant magnetic fields at a first frequency f_{12} and a second frequency f_{23} that is higher than f_{12}, the method comprising:

providing a nuclear magnetic resonance (NMR) probe circuit comprising a first resonator resonant at a frequency f_1 that is lower than f_{12}, a second resonator having a magnetic field generating component from which the resonant magnetic fields originate, the resonator being resonant at a frequency f_2 that is higher than f_1 and f_{12}, but lower than f_{23}, and third resonator resonant at a frequency f_3 that is higher than f_{23}, wherein the first, second and third resonators are arranged in the circuit relative to one another such that they are in a parallel combination or in a combination that is the electrical equivalent of a parallel combination; and

coupling a first signal at frequency f_{12} and a second signal at frequency f_{23} to the circuit such that magnetic fields are generated by the magnetic field generating element at frequency f_{12} and frequency f_{23}.